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(71) Applicant: Tonen Corporation
1-1 Hitotsubashi, 1-Chome Chiyoda-Ku
Tokyo 100(JP)

(72) Inventor: Yamazaki, Akira, Tonen Corp.Corporate Res.
Development Lab., 3-1, Nishi-Tsurugaoka 1-chome
Ohimachi, Iruma-gun, Saitama(JP)
Inventor: Kawaji, Isamu, Tonen Corp.Corporate Res.
Development Lab., 3-1, Nishi-Tsurugaoka 1-chome
Ohimachi, Iruma-gun, Saitama(JP)
Inventor: Sakakibara, Tadamori, Tonen Corp.Corporate Res.
Development Lab., 3-1, Nishi-Tsurugaoka 1-chome
Ohimachi, Iruma-gun, Saitama(JP)

(74) Representative: Baverstock, Michael George Douglas et al
BOULT, WADE & TENNANT 27 Furnival Streetet
London, EC4A 1PQ(GB)

(54) **Lubricating oil composition.**

(57) A lubricating oil composition prepared by incorporating a phosphoric acid ester. phosphorous acid ester. phosphoric acid ester amine salt or phosphorous acid ester amine salt and an aliphatic dicarboxylic acid compound into a base oil, or further incorporating an alkylamine compound and/or succinimide or perbasic magnesium or calcium sulfonate. This lubricating oil composition has excellent characteristics such that the change of the friction coefficient with the lapse of time is small and the friction coefficient is stable, and the change of the friction coefficient by the change of the oil temperature is small. This lubricating oil composition is especially valuable as a lubricating oil for an automatic transmission of an automobile.

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LUBRICATING OIL COMPOSITION

The present invention relates to a lubricating oil composition. More particularly, the present invention relates to a lubricating oil composition to be used for an automatic transmission or a wet brake, especially an automatic transmission of an automobile.

Conventional lubricating oils for automatic transmissions of automobiles (hereinafter referred to as "ATF") are divided into two types, an ATF comprising a friction modifier (hereinafter referred to as "FM") incorporated therein, represented by oils satisfying the requirements of Dexron II Standard of GM Co., and an FM-free ATF represented by oils satisfying the requirements of M2C 33F (Type F) Standard of Ford Co.

Since type F ATF does not have an FM, it is defective in that the transmission shock at the time of shifting is large and the comfort of an automobile is lowered.

Since FM is incorporated in the Dexron II type ATF, substantially no transmission shock occurs at the time of shifting in this ATF, or the transmission shock at the time of shifting is very small, if any. This state. however, is maintained only while the ATF is an almost fresh oil, and if the oil is deteriorated by heat or oxidation, the FM is consumed and the transmission shock increased.

In general, if the temperature of the ATF is low, for example, at the initial driving stage or when driving in a cold area, the transmission shock is large even if the ATF is a fresh oil. Various attempts have been made to control this transmission shock; for example, Japanese Unexamined Patent Publication No. 60-173097 proposes a lubricating oil composition comprising a base oil and, incorporated therein, (A) a trivalent or pentavelent phosphoric acid ester or an amine salt thereof and (B) at least one compound selected from the group consisting of a sorbitan fatty acid ester, a palm kernel oil fatty acid, a coconut oil fatty acid (each of the two former compounds is composed mainly of a glycerol ester of a higher fatty acid, that is, an oil and fat), a mixture of an oil and fat and a fatty acid, and a reaction product of a polyalkylene polyamine and a fatty acid (or an oxidized mineral oil). Japanese Unexamined Patent Publication No. 63-254196 proposes incorporation of a phosphoric acid ester, a phosphorous acid ester, an amine salt of a phosphoric acid ester, a carboxylic acid or a carboxylic acid amide as FM into a specific base oil. Furthermore, Japanese Unexamined Patent Publication No. 63-180000 proposes FM comprising a condensation product of an unsaturated fatty acid and an alkanolamine, Japanese Unexamined Patent Publication No. 63-66299 discloses FM comprising a combination of a fatty acid/alkanolamine reaction product and a fetty ecid or an oil and fat, and Japanese Unexamined Patent Publication No. 62-84190 proposes incorporation of magnesium sulfonate as a metallic detergent into a base oil.

Investigations have been made into the obtaining of stable lubricating oils for automatic transmissions of eutomobiles, which do not cause transmission shock for a long period, but according to these investigations, including the above-mentioned proposals, lubricating oils which are satisfactory cennot be obtained, and further improvements are desired.

The present invention is based on the concept that, to control a transmission shock at the time of shifting in an automatic transmission of an automobile, as much as possible, selection of a specific friction moderator (FM) among various additives used for an automatic transmission lubricating oil (ATF) and control of the amount used of the friction modifier are important.

To cope with the phenomenon that the FM in an ATF is gradually lost during use and a transmission shock occurs, the incorporation of a large amount of FM is considered to be effective. Nevertheless, if the FM is incorporated in too large an amount, the friction coefficient is reduced and the slip is increased at the time of connection of a clutch, with the result that the shift time becomes long, the response characteristics are poor, and a response delay or blow-out occurs. Therefore, to solve the problem of the transmission shock due to a loss of the FM, it is important to select an FM which is not substantially lost during a high-temperature operation, i.e., an FM having a high stability against heat or oxidation.

Furthermore, to solve the problem of the transmission shock at a relatively low ATF oil temperature, it is important to use an ATF in which the change of the friction coefficient, caused by the change of the temperature, is small.

Taking the above into consideration, the inventors carried out further research, and as a result, found that by skillfully combining an FM having a strong adsorption activity (the property thet the component is adsorbed on a frictional surface causing the friction to lower the friction coefficient) at a low temperature, i.e., an activity of improving the friction characteristics at a low temperature, with an FM having a strong adsorption activity at a high temperature, i.e., an activity of improving the friction characteristics at a high temperature, or further combining these FM's with a specific ash-free dispersant or metallic detergent and incorporating them into an ATF, there can be obtained an ATF composition having excellent characteristics against the change with the lapse of time and the temperature change. The present invention is based on

this finding.

In accordance with a first aspect of the present invention, there is provided a lubricating oil composition comprising a base oil and, incorporated therein, (i) at least one member selected from the group consisting of phosphoric acid esters, phosphorous acid esters and amine salts thereof represented by the following general formulae (1), (2), (3) and (4):

$$(RO)_{\ell}\,\overset{\displaystyle O}{\overset{\|}{P}}-(OH)_{3-\ell} \quad (1),$$

$$(RO)_{m}\,\overset{\displaystyle O}{\overset{\|}{P}}-(OH)_{3-m}\cdot NH_{n}R'_{3-n} \quad (2),$$

$$(RO)_{\ell}\,P-(OH)_{3-\ell} \quad (3), \text{ and}$$

$$(RO)_{m}\,P-(OH)_{3-m}\cdot NH_{n}R'_{3-n} \quad (4)$$

wherein ℓ is an integer of from 1 to 3, m and n each represent an integer of 1 or 2, and R and R', which may be the same or different, represent an alkyl, aryl or alkyl-substituted aryl group having 4 to 30 carbon atoms,

(ii) an alkylamine compound represented by the following general formula (5):

$$R''-\underset{\underset{\displaystyle R'''}{|}}{N}-R'''' \quad (5)$$

wherein R'', R''', and R'''' represent a hydrogen atom or an alkyl, aryl, alkyl-substituted aryl or alkanol group having 1 to 30 carbon atoms,

and (iii) an aliphatic dicarboxylic acid compound.

In accordance with a second aspect of the present invention, there is provided a lubricating oil composition comprising a base oil and, incorporated therein, (i) at least one member selected from the group consisting of phosphoric acid ester amine salts and phosphorous acid ester amine salts represented by the following general formulae (2) and (4):

$$(RO)_{m}\,\overset{\displaystyle O}{\overset{\|}{P}}-(OH)_{3-m}\cdot NH_{n}R'_{3-n} \quad (2),$$

and

$$(RO)_{m}\,P-(OH)_{3-m}\cdot NH_{n}R'_{3-n} \quad (4)$$

wherein m and n each represent an integer of 1 or 2, and R and R', which may be the same or different, represent an alkyl, aryl or alkyl-substituted aryl group having 4 to 30 carbon atoms,

and (iii) an aliphatic dicarboxylic acid compound.

In accordance with a third aspect of the present invention, there is provided a lubricating oil composition comprising a base oil and, incorporated therein, the following components (i), (ii), (iii) and iv), or (i), (iii) and (iv):

(i) at least one member selected from the group consisting of phosphoric acid esters, phosphorous acid esters and amine salts thereof represented by the following general formulae (1), (2), (3) and (4):

$$(RO)_{\ell}\overset{\overset{\displaystyle O}{\|}}{P}-(OH)_{3-\ell} \qquad (1),$$

$$(RO)_{m}\overset{\overset{\displaystyle O}{\|}}{P}-(OH)_{3-m}\cdot NH_{n}R'_{3-n} \qquad (2),$$

$$(RO)_{\ell}P-(OH)_{3-\ell} \qquad (3), \text{ and}$$

$$(RO)_{m}P-(OH)_{3-m}\cdot NH_{n}R'_{3-n} \qquad (4)$$

wherein ℓ is an integer of from 1 to 3, m and n each represent an integer of 1 or 2, and R and R′, which may be the same or different, represent an alkyl, aryl or alkyl-substiuted aryl group having 4 to 30 carbon atoms,

(ii) an alkylamine compound represented by the following general formula (5):

$$R''-\underset{\underset{\displaystyle R'''}{|}}{N}-R'''' \qquad (5)$$

wherein R″, R‴ and R⁗ represent a hydrogen atom or an alkyl, aryl, alkyl-substituted aryl or alkanol group having 1 to 30 carbon atoms,

(iii) an aliphatic dicarboxylic acid compound and (iv) succinimide.

In accordance with a fourth aspect of the present invention, here is provided a lubricating oil composition comprising a base oil and, incorporated therein, the following components (i), (ii), (iii) and (v), or (i), (iii) and (v):

(i) at least one member selected from the group consisting of phosphoric acid esters, phosphorous acid esters and amine salts thereof represented by the following general formulae (1), (2), (3) and (4):

$$(RO)_{\ell}\overset{\overset{\displaystyle O}{\|}}{P}-(OH)_{3-\ell} \qquad (1),$$

$$(RO)_{m}\overset{\overset{\displaystyle O}{\|}}{P}-(OH)_{3-m}\cdot NH_{n}R'_{3-n} \qquad (2),$$

$$(RO)_{\ell}P-(OH)_{3-\ell} \qquad (3), \text{ and}$$

$$(RO)_{m}P-(OH)_{3-m}\cdot NH_{n}R'_{3-n} \qquad (4)$$

wherein ℓ is an integer of from 1 to 3, m and n each represent an integer of 1 or 2, and R and R′, which may be the same or different, represent an alkyl, aryl or alkyl-substituted aryl group having 4 to 30 carbon atoms,

(ii) an alkylamine compound represented by the following general formula (5):

$$R''-\underset{\underset{\displaystyle R'''}{|}}{N}-R'''' \qquad (5)$$

wherein R″, R‴ and R⁗ represent a hydrogen atom or an alkyl, aryl, alkyl-substituted aryl or alkanol group

having 1 to 30 carbon atoms,

(iii) an aliphatic dicarboxylic acid compound and (v) perbasic magnesium or calcium sulfonate.

The FM component (i) constituting the lubricating oil composition of the present invention is at least one member selected from the group consisting of phosphoric acid esters, phosphorous acid esters and amine salts thereof represented by the above-mentioned general formulae (1), (2), (3) and (4), or at least one member selected from the group consisting of phosphoric acid ester amine salts and phosphorous acid ester amine salts represented by the above-mentioned general formulae (2) and (4). This FM component shows a strong adsorption activity at a low temperature. As specific examples of the compound of this type, there can be mentioned phosphoric acid esters such as mono-(R) phosphate, di-(R) phosphate and tri-(R) phosphate, phosphorous acid esters such as mono-(R) phosphite, di-(R) phosphite and tri-(R) phosphite, phosphoric acid ester amine salts such as di-(R) phosphate mono-(R') amine salt and mono-(R) phosphate di-(R') amine salt, and phosphorous acid ester amine salts such as mono-(R) phosphite amine salt, in which R is butyl, hexyl, octyl, decyl, lauryl, myristyl, palmityl, stearyl, oleyl, phenyl or cresyl, and R' is the same as R except that phenyl and cresyl (aryl groups) are excluded.

The FM component (ii) constituting the lubricating oil composition of the present invention is an alkylamine compound represented by the above-mentioned general formula (5). Also this FM component (ii) has a strong adsorption activity (the property that the component is adsorbed on a frictional surface causing the friction to lower the friction coefficient) at a low temperature. In the general formula (5), two or all of R'', R''' and R'''' may be the same or different.

As examples of R'', R''' and R'''', there can be mentioned alkyl groups having 1 to 30 carbon atoms, alkyl-substituted aryl groups, and alkanol groups such as ethanol and propanol groups. From the viewpoint of the oil solubility, at least one of them is preferably an alkyl or alkyl-substituted aryl group having a chain length of at least 4 carbon atoms. As specific examples of the component (ii), there can be mentioned (a) monoamines such as butylamine, pentylamine, hexylamine, octylamine, laurylamine, octadecylamine, oleylamine and stearylamine, (b) diamines such as dibutylamine, dipentylamine, dihexylamine, dioctylamine, dilaurylamine, dioctadecylamine, distearylamine, stearyl monoethanolamine, palmityl monopropanolamine, decyl monoethanolamine, hexyl monopropanolamine, phenyl monoethanolamine and tolyl monopropanolamine, and (c) triamines such as tributylamine, tripentylamine, trihexylamine, trioctylamine, trilaurylamine, trioctadecylamine, trioleylamine, tristearylamine, dioleyl monoethanolamine, dilauryl monopropanolamine, dioctyl monoethanolamine, dihexyl monopropanolamine, dibutyl monopropanolamine, oleyl diethanolamine, stearyl dipropanolamine, lauryl diethanolamine, octyl dipropanolamine, butyl diethanolamine, phenyl diethanolamine, tolyl dipropanolamine, xylyl diethanolamine, diethanolamine, and dipropanolamine.

The FM component (iii) constituting the lubricating oil composition of the present invention is an aliphatic dicarboxylic compound. This FM component shows a strong adsorption activity at a high temperature. As specific examples of this component, there can be mentioned adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, undecanedioic acid (brassylic acid), dodecanedioic acid, tetradecanedioic acid, octadecanedioic acid, eicosanedioic acid and triacontanedioic acid, and esterification products between these dicarboxylic acids or anhydrides thereof and diethylene glycol, thiodiethylene glycol or a monoalkylene glycol.

The mechanism of manifesting excellent effects by the combination of the FM components used in the present invention has not been theoretically elucidated, but it is assumed that the mechanism is probably as follows. Namely, by using FM showing a strong adsorption activity at a low temperature [components (i) and (ii) or component (i)] and FM showing a strong adsorption activity at a high temperature [component (iii)] in combination, since the amine per se has a strong adsorbing force on the adsorption surface and is basic, the amine promotes the adsorption of acidic FM (phosphoric acid ester, phosphorous acid ester or amine salt thereof) and the aliphatic carboxylic acid, and the adsorption state of FM is stabilized. It is construed that the friction-moderating effect may be enhanced for the above-mentioned reasons.

In the lubricating oil composition of the present invention, the amount of FM [components (i), (ii) and (iii) or components (i) and (iii)] is 0.01 to 2.0% by weight, preferably 0.05 to 1.0% by weight. If the amount of FM is smaller than 0.01% by weight, the FM effect is low and a transmission shock occurs. If the amount of FM is larger than 2.0% by weight, as pointed out hereinbefore, slip is increased at the time of connection of a clutch because of the presence of too large an amount of FM.

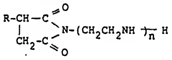
In the lubricating oil composition of the present invention, if the weight ratio of FM [components (i) and (ii)] to FM component (iii) is in a broad range of 10/90 to 90/10, the intended effect can be attained, and if this weight ratio is from 25/75 to 75/25, the attained effect is very high. Furthermore, if the FM component (i)/FM component (ii) weight ratio is from 10/90 to 90/10, the intended effect is attained, and if this weight ratio is from 25/75 to 75/25, the effect is very high. Moreover, if the FM component (i)/FM component (iii)

weight ratio is in a broad range of from 20/80 to 80/20, the intended effect is attained, and if this weight ratio is from 40/60 to 60/40, a very high effect is attained.

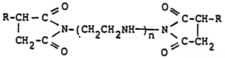
A specific ash-free dispersant is incorporated in the lubricating oil composition of the present invention, if desired. In general, an ash-free dispersant is incorporated in a lubricant of this type. It was found that an addition of succinimide is preferable because succinimide is a compound capable of improving the friction characteristics while maintaining a good sludge-dispersing property.

The reason why the succinimide improves the friction characteristics has not been elucidated, but it is assumed that the reason may be as follows. The succinimide causes competitive adsorption with FM on the friction surface and increases the initial μs (static friction coefficient) and μo (final friction coefficient)/μd (dynamic friction coefficient) while controlling the adsorption state of FM, and as a result, the succinimide gives stable friction characteristics.

As the succinimide compound, there can be mentioned mono- and bis-alkyl succinimides represented by the following general formulae:



(mono-type) (6), and



(bis-type) (7)

wherein R represents an oligomer residue having a molecular weight of about 3000 and n is an integer of from 4 to 6,
and B-blocked succinimide. Among the above, B-blocked succinimide is most preferably used.

The amount added of the component (iv) is preferably 1.00 to 10.00% by weight, most preferably 2.00 to 5.00% by weight. If the amount added of the component (iv) is smaller than 1.00% by weight, the dispersibility of deterioration products is poor, and μs is reduced by the adsorption of FM. If the amount added of the component (iv) is larger then 10.00% by weight, $\mu o/\mu d$ is reduced by inhibition of the adsorption of FM and the friction characteristics are poor, and the abrasion resistance is low.

Furthermore, a specific metallic detergent (v) is incorporated in the lubricating oil composition of the present invention, if desired. In general, a metallic detergent is incorporated in a lubricating oil of this type. According to the present invention, it was found that an incorporation of a perbasic sulfonate is preferable for improving the friction characteristics while maintaining the cleanliness. The reason why the perbasic value sulfonate exerts the effect of improving the friction characteristics has not been elucidated, but it is assumed that the reason may be as follows. There are neutral and basic sulfonates, but it is considered that the perbasic value sulfonate controls the absorption state of FM by its strong basicity and exerts not only the effect of increasing μd (dynamic friction coefficient) but also the effect of reducing μo (final friction coefficients/μd, which is the index of comfort (generation of transmission shock).

As the perbasic value sulfonate compound, there can be mentioned perbasic value magnesium sulfonate and perbasic value calcium sulfonate. By the perbasic value compound is meant a compound having a TBN (total base number) value of at least 300.

The amount added of the component (v) is preferably 0.05 to 1.00% by weight, most preferably 0.10 to 0.50% by weight. If the amount added of the component (v) is 0.05% by weight, the cleaning effect is poor, and μd and μs are decreased and $\mu o/\mu d$ is increased, resulting in a reduction of the friction characteristics. If the amount added of the component (v) exceeds 1.00% by weight, μs is decreased and the friction characteristics are poor, and simultaneously, the abrasion resistance is low.

In the lubricating oil composition of the present invention, known mineral oils and synthetic oils can be used as the base oil to which the above-mentioned components are added.

Solvent-refined or hydrofinished 60 neutral oil, 100 neutral oil, 150 neutral oil, 300 neutral oil and 500 neutral oil, and low-pouring-point base oils having a low-temperature flowability improved by removing wax components from these base oils can be mentioned as the mineral oil. These mineral oils can be used

alone or in the form of mixtures comprising two or more thereof at appropriate ratios.

As the synthetic oil, there can be mentioned poly-α-olefin oligomers, diesters, polyol esters and polyalkylene glycol. These base oils are generally used alone, but can be used in combination with the above-mentioned mineral oils. The synthetic oil/mineral oil mixing ratio is, for example, from 80/20 to 20/80.

In the present invention, the viscosity of the base oil is preferably 3 to 20 cSt as measured at 100 °C.

The lubricating oil composition of the present invention may further comprise an antiwear agent selected from primary zinc thiophosphate, secondary zinc thiophosphate and zinc allyl thiophosphate, an ash-free dispersant such as benzylamine, a metallic detergent selected from magnesium sulfonate, calcium sulfonate and barium sulfonate, a viscosity improver and an anti-oxidant.

The lubricating oil composition of the present invention is characterized in that the change with time of the friction coefficient is small and the composition is stable, and the change of the friction coefficient by the change of the oil temperature is small. Accordingly, the composition is especially valuable as a lubricant for an automatic transmission of an automobile. Moreover, at the transmission shock sensory test on an actual automobile, it was found that when the lubricating oil composition of the present invention is used, the transmission shock is controlled at the time of shifting and a very good comfort is attained.

The present invention will now be described in detail with reference to the following examples, that by no means limit the scope of the invention.

Examples 1 through 14 and Comparative Examples 1 through 12

Sample oils were prepared by using variable amounts of FM (i), FM (ii), FM (iii), FM (iv) and FM (v) as friction moderators (the total amount was 0.5% by weight), other components shown and a base oil (refined mineral oil having a viscosity of 4.0 cSt as measured at 100 °C) as the common balance, as shown in Table 1 given below.

The friction characteristics of these sample oils were measured by using a friction tester (Model SAE No. 2 supplied by Automax Co., Japan).

The friction test included a dynamic test and a static test. From the torque curves obtained at the respective tests, the torque value Td (dynamic friction torque), the torque value To final friction torque) and the torque value Ts (static friction torque were determined, and the corresponding friction coefficients μd (dynamic friction coefficient), μo (final friction coefficient) and μs (static friction coefficient were calculated according to the following formula (1):

$T = nr\mu F$ (1)

wherein T represents the torque, n represents the number of planes, μ represents the friction coefficient, and F represents the pressing force.

The results are shown in Table 1.

Table 1-1

			Example No.					
			1	2	3	4	5	6
Composition (% by weight)	FM (i)	dioleyl phosphate amine salt						
		dilauryl phosphate amine salt						
		mono-oleyl phosphate amine salt						
		monolauryl phosphate amine salt						
		diolayl phosphata		0.25			0.05	
		dioctyl phosphate				0.20		
		dilauryl phosphate	0.30		0.20			
		mono-oleyl phosphate						0.15
	FM (ii)	laurylamine				0.10		0.15
		oleylamine			0.10		0.15	
		butylamine		0.10				
		oleyldiethanolamine	0.05					
	FM (iii)	octadecanedioic acid						
		dodecanedioic acid	0.15		0.20			
		eicosanedioic acid		0.15		0.20		
		*2					0.30	0.20
	antiwear agent	secondary zinc thiophosphate	0.4	0.4	0.4	0.4	0.4	0.4
	metallic detergent	magnesium sulfonate *1	0.3	0.3	0.3	0.3	0.3	0.3
	ash-free dispersant	benzylamine	3.0	3.0	3.0	3.0	3.0	3.0

*1: magnesium sulfonate (basic value - 100)

*2: product obtained by reaction represented by the formula

$$2(\mathrm{HOOC\text{-}R\text{-}COOH}) + \mathrm{HO\text{-}R'\text{-}OH} \rightarrow \mathrm{HOOC\text{-}R\text{-}}\underset{\underset{\displaystyle O}{\|}}{\mathrm{C}}\mathrm{\text{-}O\text{-}R'\text{-}O\text{-}}\underset{\underset{\displaystyle O}{\|}}{\mathrm{C}}\mathrm{\text{-}R\text{-}COOH}$$

Table 1-1 (continued)

				Example No.					
				1	2	3	4	5	6
Results	SAE Test No. 2	500 cycles	μs	0.125	0.129	0.132	0.133	0.132	0.129
			μd	0.128	0.132	0.130	0.135	0.136	0.135
			$\mu o/\mu d$	1.016	1.068	1.054	1.060	1.059	1.030
		5000 cycles	μs	0.133	0.137	0.138	0.142	0.140	0.139
			μd	0.130	0.134	0.133	0.139	0.142	0.140
			$\mu o/\mu d$	1.031	1.067	1.068	1.065	1.042	1.043
	Stability against change with lapse of time			good	good	good	good	good	good
	SAE Test No. 2 (after 5000 cycles)	60°C	μs	0.138	0.140	0.142	0.146	0.145	0.143
			μd	0.130	0.134	0.134	0.142	0.140	0.141
			$\mu o/\mu d$	1.038	1.067	1.067	1.064	1.034	1.050
		100°C	μs	0.133	0.137	0.138	0.142	0.140	0.139
			μd	0.130	0.134	0.133	0.139	0.142	0.140
			$\mu o/\mu d$	1.031	1.067	1.068	1.065	1.042	1.043
		120°C	μs	0.127	0.131	0.134	0.136	0.134	0.133
			μd	0.128	0.130	0.132	0.137	0.139	0.132
			$\mu o/\mu d$	1.031	1.046	1.053	1.051	1.029	1.038
	Stability against change of temperature			good	good	good	good	good	good

Table 1-2

			Example No.							
			7	8	9	10	11	12	13	14
Compo-sition (% by weight)	FM (i)	dioleyl phosphate amine salt						0.2		
		dilauryl phosphate amine salt				0.20			0.05	
		mono-oleyl phosphate amine salt								0.10
		monolauryl phosphate amine salt			0.10		0.10			
		dioleyl phosphate	0.05							
		dioctyl phosphate								
		dilauryl phosphate								
		mono-oleyl phosphate		0.15						
	FM (ii)	laurylamine					0.20			
		oleylamine						0.10		
		butylamine		0.15		0.10				0.20
		oleyldiethanolamine	0.15		0.20				0.15	
	FM (iii)	octadecanedioic acid							0.30	
		dodecanedioic acid						0.20		
		eicosanedioic acid					0.20			0.20
		*2	0.30	0.20	0.20	0.20				
	antiwear agent	secondary zinc thiophosphate	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	metallic detergent	magnesium sulfonate *1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	ash-free dispersant	benzylamine	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

*1: magnesium sulfonate (basic value = 100)

*2: product obtained by reaction represented by the formula

$$2(\mathrm{HOOC{-}R{-}COOH}) + \mathrm{HO{-}R''{-}OH} \rightarrow \mathrm{HOOC{-}R{-}}\underset{\underset{\mathrm{O}}{\|}}{\mathrm{C}}\mathrm{{-}O{-}R''{-}O{-}}\underset{\underset{\mathrm{O}}{\|}}{\mathrm{C}}\mathrm{{-}R{-}COOH}$$

Table 1-2 (continued)

				Example No. 7	8	9	10	11	12	13	14
Results	SAE Test No. 2	500 cycles	μs	0.130	0.127	0.132	0.126	0.133	0.128	0.125	0.120
			μd	0.134	0.130	0.135	0.132	0.136	0.132	0.136	0.132
			μo/μd	1.015	1.015	1.022	1.000	1.037	1.007	1.022	1.023
		5000 cycles	μs	0.140	0.136	0.142	0.130	0.140	0.133	0.135	0.130
			μd	0.140	0.135	0.139	0.138	0.140	0.138	0.139	0.135
			μo/μd	1.036	1.030	1.043	1.007	1.050	1.014	1.014	1.037
	Stability against change with lapse of time			good	good	good	good	good	good	good	good
	SAE Test No. 2 (after 5000 cycles)	60°C	μs	0.144	0.142	0.146	0.135	0.147	0.138	0.140	0.135
			μd	0.142	0.136	0.139	0.138	0.141	0.138	0.139	0.135
			μo/μd	1.049	1.059	1.058	1.022	1.057	1.022	1.022	1.044
		100°C	μs	0.140	0.136	0.142	0.130	0.140	0.133	0.135	0.130
			μd	0.140	0.135	0.139	0.138	0.140	0.138	0.139	0.135
			μo/μd	1.036	1.030	1.043	1.007	1.050	1.014	1.014	1.037
		120°C	μs	0.135	0.133	0.137	0.127	0.138	0.129	0.132	0.126
			μd	0.139	0.133	0.138	0.137	0.139	0.130	0.135	0.134
			μo/μd	1.029	1.030	1.029	1.000	1.043	1.015	1.007	1.022
	Stability against change of temperature			good	good	good	good	good	good	good	good

Table 1-2

			Comparative Example No.											
			1	2	3	4	5	6	7	8	9	10	11	12
Composition (% by weight)	TM (i)	dioleyl phosphate amine salt	0.25											
		dilauryl phosphate amine salt									0.20			
		coco-oleyl phosphate amine salt	0.75											
		dioleyl phosphate						0.25						
		dioctyl phosphate					0.40							0.15
		dilauryl phosphate			0.40									
		mono-oleyl phosphate								0.20				
	TM (ii)	oleylamine						0.25	0.10				0.10	0.15
		butylamine										0.30		
		oleyldiethanolamine			0.10	0.40					0.30			
	TM (iii)	octenedioic acid		0.50										
		dodecenedioic acid				0.10							0.10	
		eicosenedioic acid					0.10							
		*2							0.40	0.30				
	TM (iv)	oleic acid										0.20		0.20
	TM (v)	oleyl alcohol											0.30	
	antiwear agent	secondary zinc thiophosphate	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	metallic detergent	magnesium sulfonate *1	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	ash-free dispersant	benzylamine	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

*1: magnesium sulfonate (basic value - 100)

*2: product obtained by reaction represented by the formula

$$2(HOOC\text{-}R\text{-}COOH)+HO\text{-}R'\text{-}OH \rightarrow HOOC\text{-}R\text{-}\underset{\underset{O}{\|}}{C}\text{-}O\text{-}R'\text{-}O\text{-}\underset{\underset{O}{\|}}{C}\text{-}R\text{-}COOH$$

Table 1-3 (continued)

				Comparative Example No.											
				1	2	3	4	5	6	7	8	9	10	11	12
Results	SAE Test No. 2	500 cycles	μ_s	0.128	0.135	0.123	0.120	0.122	0.127	0.128	0.124	0.123	0.129	0.120	0.121
			μ_d	0.129	0.130	0.127	0.129	0.128	0.130	0.131	0.127	0.128	0.132	0.124	0.122
			μ_s/μ_d	1.046	1.069	1.008	1.008	1.008	1.015	1.038	1.031	1.000	1.045	1.024	1.083
		5000 cycles	μ_s	0.140	0.141	0.135	0.140	0.133	0.139	0.136	0.132	0.135	0.141	0.131	0.135
			μ_d	0.133	0.135	0.132	0.136	0.130	0.139	0.133	0.129	0.134	0.133	0.130	0.133
			μ_s/μ_d	1.038	1.074	1.023	1.059	1.060	1.043	1.060	1.039	1.030	1.068	1.036	1.067
	Stability against change with lapse of time			bad	good	bad	bad	bad	bad	good	good	bad	bad	fair	bad
	SAE Test No. 2 (after 5000 cycles)	60°C	μ_s	0.146	0.142	0.143	0.146	0.143	0.144	0.147	0.140	0.138	0.146	0.135	0.139
			μ_d	0.134	0.150	0.134	0.137	0.132	0.144	0.135	0.135	0.136	0.137	0.133	0.134
			μ_s/μ_d	1.045	1.086	1.037	1.066	1.081	1.076	1.081	1.044	1.051	1.073	1.053	1.075
		100°C	μ_s	0.140	0.141	0.135	0.140	0.133	0.139	0.136	0.132	0.135	0.141	0.131	0.135
			μ_d	0.133	0.135	0.132	0.136	0.130	0.139	0.133	0.129	0.134	0.133	0.130	0.133
			μ_s/μ_d	1.038	1.074	1.023	1.059	1.060	1.043	1.060	1.039	1.030	1.068	1.036	1.067
		120°C	μ_s	0.136	0.133	0.133	0.130	0.127	0.135	0.130	0.127	0.130	0.135	0.125	0.129
			μ_d	0.132	0.128	0.130	0.130	0.129	0.133	0.132	0.128	0.133	0.130	0.129	0.128
			μ_s/μ_d	1.022	1.062	1.015	1.054	1.046	1.022	1.046	1.016	1.022	1.062	1.029	1.055
	Stability against change of temperature			good	bad	good	bad	bad	good	bad	bad	good	fair	fair	good

From the results shown in Table 1, it is seen that ATF of the present invention, i.e., ATF prepared by incorporating appropriate amounts of two FM components having an excellent stability against heat or oxidation and showing a strong adsorption activity at a low temperature and one FM component showing an adsorption activity at a high temperature, is characterized in that at the friction test using SAE Tester No. 2, the change with the lapse of time is small and the friction coefficient is stable, and the friction coefficients measured while changing the oil temperature are stable.

Examples 15 through 18 and Comparative Examples 13 through 16

Sample oils were prepared by using variable amounts of FM (i), FM (ii), oleyl alcohol as FM (iii) and an aliphatic monocarboxylic acid as FM (iv) as the friction moderators (the total amount was 0.5% by weight), other components shown and a base oil (refined mineral oil having a viscosity of 4.0 cSt as measured at 100 °C) as the common balance, as shown in Table 2.

The friction characteristics of the prepared sample oils were measured by using a friction tester (SAE No. 2 supplied by Automax Co., Japan).

The results are shown in Table 2.

Table 2

			Example No.				Comparative Example No.			
			15	16	17	18	13	14	15	16
Composition (% by weight)	FM (i)	dioleyl phosphate amine salt	0.30				0.25			
		dilauryl phosphate amine salt			0.30					0.30
		mono-oleyl phosphate amine salt		0.40			0.25			
		monolauryl phosphate amine salt				0.20				
	FM (ii)	octadecanedioic acid	0.20					0.5		
		eicosanedioic acid		0.10					0.10	
		*2			0.20	0.30				
	FM (iii)	oleyl alcohol							0.40	
	FM (iv)	oleic acid								0.20
	antiwear agent	secondary zinc thiophosphate	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	metallic detergent	magnesium sulfonate *1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	ash-free dispersant	benzylamine	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

*1: magnesium sulfonate (basic value = 100)

*2: product obtained by reaction represented by the formula

$$2(HOOC{-}R{-}COOH)+HO{-}R'{-}OH \rightarrow HOOC{-}R{-}\underset{\substack{\|\\ O}}{C}{-}O{-}R'{-}O{-}\underset{\substack{\|\\ O}}{C}{-}R{-}COOH$$

Table 2 (continued)

				Example No.				Comparative Example No.			
				15	16	17	18	13	14	15	16
Results	SAE Test No. 2	500 cycles	μs	0.130	0.134	0.132	0.128	0.128	0.135	0.125	0.123
			μd	0.133	0.135	0.135	0.131	0.129	0.130	0.128	0.130
			μo/μd	1.053	1.067	1.044	1.015	1.046	1.069	1.047	1.023
		5000 cycles	μs	0.139	0.142	0.140	0.137	0.150	0.141	0.138	0.137
			μd	0.136	0.139	0.140	0.135	0.133	0.135	0.132	0.134
			μo/μd	1.066	1.065	1.064	1.030	1.083	1.074	1.076	1.060
	Stability against change with lapse of time			good	good	good	good	bad	good	bad	bad
	SAE Test No. 2 (after 5000 cycles)	60°C	μs	0.143	0.147	0.144	0.142	0.153	0.142	0.146	0.140
			μd	0.141	0.143	0.141	0.136	0.134	0.152	0.133	0.134
			μo/μd	1.056	1.056	1.064	1.037	1.090	1.086	1.090	1.075
		100°C	μs	0.139	0.142	0.140	0.137	0.150	0.141	0.138	0.137
			μd	0.136	0.139	0.140	0.135	0.133	0.135	0.132	0.134
			μo/μd	1.066	1.058	1.064	1.030	1.083	1.074	1.076	1.060
		120°C	μs	0.134	0.138	0.135	0.134	0.146	0.133	0.133	0.132
			μd	0.135	0.134	0.137	0.133	0.131	0.128	0.130	0.133
			μo/μd	1.059	1.045	1.058	1.022	1.069	1.062	1.062	1.053
	Stability against change of temperature			good	good	good	good	good	bad	bad	good

From the results shown in Table 2, it is seen that ATF of the present invention, i.e., ATF prepared by incorporating appropriate amounts of the FM component having an excellent stability against heat or oxidation and showing a strong adsorption activity at a low temperature and the FM component showing a strong adsorption activity at a high temperature, is characterized in that at the friction test using SAE Tester No. 2, the change with the lapse of time is small and the friction coefficient is stable, and the friction coefficients measured while changing the oil temperature are stable.

Examples 19 through 23 and Comparative Examples 17 through 19

Sample oils were prepared by using variable amounts of FM (i), FM (ii) and FM (iii) as the friction moderators (the total amount was 0.5% by weight), changing the kind of the ash-free dispersant, using other components shown and a base oil (refined mineral oil having a viscosity of 4.0 cSt as measured at 100 °C) as the common balance, as shown in Table 3.

The friction characteristics of the obtained sample oils were measured by a friction tester (SAE No. 2 supplied by Automax Co., Japan). The results are shown in Table 3.

Table 3

			Example No.					Comparative Example No.		
			19	20	21	22	23	17	18	19
Compo-sition (% by weight)	FM (i)	dioleyl phosphate amine salt	0.15	0.30			0.30	0.15		
		dibutyl phosphate								
		dioctyl phosphate				0.05				0.05
		dilauryl phosphate			0.30				0.30	
	FM (ii)	oleylamine				0.15				0.15
		oleyldiethanolamine			0.05				0.05	
	FM (iii)	octanedioic acid	0.35					0.35		
		dodecanedioic acid			0.15				0.15	
		*4		0.20		0.30	0.20			0.30
	antiwear agent	secondary zinc thiophosphate	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table 3 (continued)

			Example No.					Comparative Example No.		
			19	20	21	22	23	17	18	19
Composition (% by weight)	metallic detergent	magnesium sulfonate *1	0.10	0.50	0.10	0.50		0.1	0.1	
		calcium sulfonate *2					0.5			
		barium sulfonate *3								0.4
	ash-free dispersant	B-blocked succinimide	3.0	3.0	3.0	3.0	3.0			
		benzylamine						3.0	3.0	3.0

*1: magnesium sulfonate (basic value = 100)
*2: neutral calcium sulfonate
*3: neutral barium sulfonate
*4: product obtained by reaction represented by the formula

$$2(\mathrm{HOOC\text{-}R\text{-}COOH})+\mathrm{HO\text{-}R'\text{-}OH} \rightarrow \mathrm{HOOC\text{-}R\text{-}\underset{\underset{O}{\|}}{C}\text{-}O\text{-}R'\text{-}O\text{-}\underset{\underset{O}{\|}}{C}\text{-}R\text{-}COOH}$$

Table 3 (continued)

				Example No.					Comparative Example No.		
				19	20	21	22	23	17	18	19
Results	SAE Test No. 2	500 cycles	μs	0.127	0.135	0.125	0.132	0.137	0.122	0.121	0.131
			μd	0.127	0.135	0.128	0.133	0.134	0.130	0.125	0.129
			μo/μd	1.055	1.022	1.047	1.060	1.037	1.069	1.056	1.085
		5000 cycles	μs	0.133	0.141	0.128	0.140	0.140	0.134	0.136	0.142
			μd	0.132	0.138	0.130	0.137	0.131	0.140	0.127	0.132
			μo/μd	1.063	1.015	1.062	1.058	1.030	1.057	1.087	1.091
	Stability against change with lapse of time			good	good	good	good	good	fair	bad	fair
	SAE Test No. 2 (after 5000 cycles)	60°C	μs	0.136	0.140	0.137	0.143	0.137	0.137	0.138	0.149
			μd	0.134	0.139	0.127	0.134	0.132	0.131	0.127	0.136
			μo/μd	1.060	1.022	1.063	1.060	1.045	1.068	1.094	1.096
		100°C	μs	0.133	0.141	0.128	0.140	0.140	0.134	0.136	0.142
			μd	0.132	0.138	0.125	0.137	0.131	0.140	0.127	0.132
			μo/μd	1.063	1.015	1.064	1.058	1.030	1.057	1.087	1.091
		120°C	μs	0.130	0.134	0.127	0.136	0.128	0.130	0.134	0.139
			μd	0.131	0.136	0.124	0.137	0.129	0.129	0.124	0.131
			μo/μd	1.046	1.015	1.056	1.051	1.023	1.054	1.081	1.084
	Stability against change of temperature			good	good	good	good	good	good	good	good

From the results shown in Table 3, it is seen that ATF of the present invention, i.e., ATF prepared by using appropriate amounts of the FM component having an excellent stability against heat or oxidation and showing a strong adsorption activity at a low temperature and the FM component showing a strong adsorption activity at a high temperature and incorporating a specific ash-free dispersant, is characterized in that at the friction test using SAE Tester No. 2, the change with the lapse of time is small and the friction coefficient is stable, and the friction coefficients measured while changing the oil temperature are stable.

Examples 24 through 28 and Comparative Examples 20 through 22

Sample oils were prepared by using variable amounts of FM (i), FM (ii) and FM (iii) as the friction moderators (the total amount was 0.5% by weight), changing the kind of the metallic detergent, and using other components shown and a base oil (refined mineral oil having a viscosity of 4.0 cSt as measured at 100 °C) as the common balance, as shown in Table 4.

The friction characteristics of the prepared sample oils were measured by using a friction tester (SAE No. 2 supplied by Automax Co., Japan). The results are shown in Table 4.

Table 4

			Example No.					Comparative Example No.		
			24	25	26	27	28	20	21	22
Composition (% by weight)	FM (i)	dibutyl phosphate amine salt	0.15	0.30				0.15		
		dioctyl phosphate				0.05	0.05			0.05
		dilauryl phosphate			0.40				0.30	
		mono-oleyl phosphate								
	FM (ii)	laurylamine				0.15	0.15			
		oleylamine								0.15
		oleylethanolamine								
		oleyldiethanolamine			0.05				0.05	
	FM (iii)	octadecanedioic acid	0.35					0.35		
		dodecanedioic acid			0.05				0.15	
		*2		0.20		0.30	0.30			0.30
	antiwear agent	secondary zinc thiophosphate	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	metallic detergent (iv)	perbasic value magnesium sulfonate*3	0.3	0.3	0.3	0.3				
		perbasic value calcium sulfonate*4					0.3			
		magnesium sulfonate *1						0.3	0.3	0.3
	ash-free dispersant	benzylamine	1.0	5.0	1.0	5.0	1.0	1.0	1.0	1.0

*1: magnesium sulfonate (basic value = 100)

*2: product obtained by reaction represented by the formula

$$2(HOOC\text{-}R\text{-}COOH) + HO\text{-}R'\text{-}OH \rightarrow HOOC\text{-}R\text{-}\underset{\underset{O}{\|}}{C}\text{-}O\text{-}R'\text{-}O\text{-}\underset{\underset{O}{\|}}{C}\text{-}COOH$$

*3: total base number = 395

*4: total base number = 305

Table 4 (continued)

				Example No.					Comparative Example No.		
				24	25	26	27	28	20	21	22
Results	SAE Test No. 2	500 cycles	μs	0.127	0.138	0.122	0.137	0.135	0.115	0.108	0.125
			μd	0.129	0.136	0.123	0.137	0.133	0.127	0.121	0.135
			$\mu o/\mu d$	1.023	1.051	1.008	1.066	1.038	0.976	0.959	0.970
		5000 cycles	μs	0.134	0.145	0.128	0.145	0.141	0.129	0.118	0.137
			μd	0.134	0.143	0.126	0.141	0.131	0.132	0.124	0.138
			$\mu o/\mu d$	1.000	1.063	1.024	1.064	1.023	0.985	0.976	0.986
	Stability against change with lapse of time			good	good	good	good	good	fair	fair	fair
	SAE Test No. 2 (after 5000 cycles)	60°C	μs	0.138	0.146	0.133	0.147	0.145	0.132	0.123	0.139
			μd	0.135	0.143	0.128	0.143	0.132	0.133	0.126	0.139
			$\mu o/\mu d$	1.037	1.070	1.054	1.063	1.038	0.992	0.992	1.000
		100°C	μs	0.134	0.145	0.128	0.147	0.141	0.129	0.118	0.137
			μd	0.134	0.143	0.126	0.141	0.131	0.132	0.124	0.138
			$\mu o/\mu d$	1.000	1.063	1.024	1.064	1.023	0.985	0.976	0.986
		120°C	μs	0.132	0.138	0.126	0.142	0.138	0.127	0.115	0.133
			μd	0.133	0.142	0.125	0.141	0.130	0.127	0.120	0.137
			$\mu o/\mu d$	1.000	1.049	1.016	1.042	1.015	0.984	0.967	0.985
	Stability against change of temperature			good	good	good	good	good	good	good	good

From the results shown in Table 4, it is seen that ATF of the present invention, i.e., ATF prepared by using appropriate amounts of the FM component having an excellent stability against heat or oxidation and showing a strong adsorption activity at a low temperature and the FM component showing a strong adsorption activity at a high temperature and incorporating a specific metallic detergent, is characterized in that at the friction test using SAE Tester No. 2, the change with the lapse of time is small and the friction coefficient is stable, and the friction coefficients measured while changing the oil temperature are stable.

Claims

1. A lubricating oil composition comprising a base oil and, incorporated therein, (i) at least one member selected from the group consisting of phosphoric acid esters, phosphorous acid esters and amine salts thereof represented by the following general formulae (1), (2), (3) and (4):

$$(RO)_{\ell}\overset{\displaystyle O}{\overset{\|}{P}}\text{-}(OH)_{3-\ell} \qquad (1),$$

$$(RO)_{m}\overset{\displaystyle O}{\overset{\|}{P}}\text{-}(OH)_{3-m}\cdot NH_{n}R'_{3-n} \qquad (2),$$

$$(RO)_{\ell}P\text{-}(OH)_{3-\ell} \qquad (3),\ \text{and}$$

$$(RO)_{m}P\text{-}(OH)_{3-m}\cdot NH_{n}R'_{3-n} \qquad (4)$$

wherein ℓ is an integer of from 1 to 3, m and n each represent an integer of 1 or 2, and R and R', which may be the same or different, represent an alkyl, aryl or alkyl-substituted aryl group having 4 to 30 carbon atoms,

(ii) an alkylamine compound represented by the following general formula (5):

$$R''\text{-}\underset{\underset{\displaystyle R'''}{|}}{N}\text{-}R'''' \qquad (5)$$

wherein R'', R''' and R'''' represent a hydrogen atom or an alkyl, aryl, alkyl-substituted aryl or alkanol group having 1 to 30 carbon atoms,

and (iii) an aliphatic dicarboxylic acid compound.

2. A lubricating oil composition comprising a base oil and, incorporated therein, (i) at least one member selected from the group consisting of phosphoric acid ester amine salts and phosphorous acid ester amine salts represented by the following general formulae (2 and (4):

$$(RO)_{m}\overset{\displaystyle O}{\overset{\|}{P}}\text{-}(OH)_{3-m}\cdot NH_{n}R'_{3-n} \qquad (2),$$

and

$$(RO)_{m}P\text{-}(OH)_{3-m}\cdot NH_{n}R'_{3-n} \qquad (4)$$

wherein m and n each represent an integer of 1 or 2, and R and R′, which may be the same or different, represent an alkyl, aryl or alkyl-substituted aryl group having 4 to 30 carbon atoms,
and (iii) an aliphatic dicarboxylic acid compound.

3. A lubricating oil composition comprising a base oil and, incorporated therein, the following components (i), (ii), (iii) and (iv), or (i), (iii) and (iv):
(i) at least one member selected from the group consisting of phosphoric acid esters, phosphorous acid esters and amine salts thereof represented by the following general formulae (1), (2), (3) and (4):

$$(RO)_{\ell}\overset{O}{\overset{\|}{P}}-(OH)_{3-\ell} \qquad (1),$$

$$(RO)_{m}\overset{O}{\overset{\|}{P}}-(OH)_{3-m}\cdot NH_{n}R'_{3-n} \qquad (2),$$

$$(RO)_{\ell}P-(OH)_{3-\ell} \qquad (3),\ \text{and}$$

$$(RO)_{m}P-(OH)_{3-m}\cdot NH_{n}R'_{3-n} \qquad (4)$$

wherein ℓ is an integer of from 1 to 3, m and n each represent an integer of 1 or 2, and R and R′, which may be the same or different, represent an alkyl, aryl or alkyl-substituted aryl group having 4 to 30 carbon atoms,
(ii) an alkylamine compound represented by the following general formula (5):

$$\begin{array}{c} R''-N-R'''' \\ | \\ R''' \end{array} \qquad (5)$$

wherein R″, R‴ and R⁗ represent a hydrogen atom or an alkyl, aryl, alkyl-substituted aryl or alkanol group having 1 to 30 carbon atoms,
(iii) an aliphatic dicarboxylic acid compound and
(iv) succinimide.

4. A lubricating oil composition comprising a base oil and, incorporated therein, the following components (i), (ii), (iii) and (v), or (i), (iii) and (v):
(i) at least one member selected from the group consisting of phosphoric acid esters, phosphorous acid esters and amine salts thereof represented by the following general formulae (1), (2), (3) and (4):

$$(RO)_{\ell}\overset{O}{\overset{\|}{P}}-(OH)_{3-\ell} \qquad (1),$$

$$(RO)_{m}\overset{O}{\overset{\|}{P}}-(OH)_{3-m}\cdot NH_{n}R'_{3-n} \qquad (2),$$

$$(RO)_{\ell}P-(OH)_{3-\ell} \qquad (3),\ \text{and}$$

$$(RO)_{m}P-(OH)_{3-m}\cdot NH_{n}R'_{3-n} \qquad (4)$$

wherein ℓ is an integer of from 1 to 3, m and n each represent an integer of 1 or 2, and R and R′, which may be the same or different, represent an alkyl, aryl or alkyl-substituted aryl group having 4 to 30 carbon atoms,
(ii) an alkylamine compound represented by the following general formula (5):

$$\begin{array}{c} R''-N-R'''' \\ | \\ R''' \end{array} \qquad (5)$$

wherein R'', R''' and R'''' represent a hydrogen atom or an alkyl, aryl, alkyl-substituted aryl or alkanol group having 1 to 30 carbon atoms,

(iii) an aliphatic dicarboxylic acid compound and

(v) perbasic magnesium or calcium sulfonate.

5. A composition as claimed in any one of claims 1 to 4, wherein the base oil comprises at least one mineral oil selected from the group consisting of solvent-refined or hydro-finished 60 neutral oil, 100 neutral oil, 150 neutral oil, 300 neutral oil and 500 neutral oil, and low-pour-point base oils having an improved low-temperature flowability, which are obtained by removing wax components from said mineral oils.

6. A composition as claimed in any one of claims 1 to 4, wherein the base oil comprises a synthetic oil selected from the group consisting of poly-α-olefin oligomers, diesters, polyol esters and polyalkylene glycol.

7. A composition as claimed in any one of claims 1 to 4, wherein the base oil is a mixture of a mineral oil as claimed in claim 5 and a synthetic oil as claimed in claim 6.

8. A composition as claimed in claim 7, wherein the synthetic oil/mineral oil mixing ratio is in the range of from 80/20 to 20/80.

9. A composition as claimed in any one of the preceding claims wherein the viscosity of the bese oil is 3 to 20 cSt as measured at 100 °C.

10. A composition as claimed in any one of the preceding claims, wherein the component (i) comprises e phosphoric acid ester selected from the group consisting of mono-(R) phosphetes, di-(R) phosphates and tri-(R) phosphates, in which R is butyl, hexyl, octyl, decyl, lauryl, myristyl, palmityl, stearyl, oleyl, phenyl or cresyl.

11. A composition as claimed in any one of claims 1 to 9, wherein the component (i) comprises a phosphorous acid ester selected from the group consisting of mono-(R) phosphites, di-(R) phosphites and tri-(R) phosphites, in which R is butyl, hexyl, octyl, decyl, lauryl, myristyl, palmityl, stearyl, oleyl, phenyl or cresyl.

12. A composition as claimed in any one of claims 1 to 9, wherein the component (i) comprises a phosphoric acid ester emine salt selected from the group consisting of di-(R) phosphate mono-(R′) amine selts and mono-(R) phosphate di-(R′) amine salts, in which R is butyl, hexyl, octyl, decyl, leuryl, myristyl, pelmityl, stearyl, oleyl, phenyl or eresyl, and R′ is butyl, hexyl, octyl, decyl, lauryl, myristyl, palmityl, stearyl or oleyl.

13. A composition as claimed in any one of claims 1 to 9, wherein the component (i) comprises a phosphorous acid ester amine salt selected from the group consisting of mono-(R) phosphite amine salts, in which R is butyl, hexyl, octyl, decyl, lauryl, myristyl, palmityl, stearyl, oleyl, phenyl or cresyl.

14. A composition as claimed in any one of the preceding claims, wherein at least one of R'', R''', and R'''' in the formula (5) is an alkyl group or alkyl-substituted aryl group having at least 4 carbon atoms.

15. A composition as claimed in claim 14, wherein the component (ii) comprises e monoamine selected from the group consisting of butylamine, pentylamine, hexylamine, octylamine, laurylamine, octadecylamine, oleylamine and stearylamine.

16. A composition as claimed in claim 14, wherein the component (ii) comprises a diamine selected from the group consisting of dibutylamine, dipentylamine, dihexylamine, dioctylamine, dilaurylamine, diotadecylamine, distearylamine, stearylmonoethanolamine, palmitylpropanolamine, decylmonoethanolamine, hexylmonopropanolamine, phenylmonoethanolamine and tolylmonopropanolamine.

17. A composition as claimed in claim 14, wherein the component (ii) comprises a triamine selected from the group consisting of tributylamine, tripentylamine, trihexylamine, trioctylamine, trilaurylamine, trioctadecylamine, trioleylamine, tristearylamine, dioleylmonoethanolamine, dilaurylmonopropanolamine, dioctylmonoethanolamine, dihexylmonopropanolamine, dibutylmonopropanolamine, oleyldiethanolamine, stearyldipropanolamine, lauryldiethanolamine, octyldipropanolamine, butyldiethanolamine, phenyldiethanolamine, tolyldipropanolamine, xylyldiethanolamine, diethanolamine and dipropanolamine.

18. A composition as claimed in any one of the preceding claims, wherein the aliphatic dicarboxylic acid compound as the component (iii) is selected from the group consisting of adipic acid, pimelic acid. suberic acid, azelaic acid, sebacic acid, undecanedionic acid (brassylic acid), dodecanedioic acid, tetradecanedioic acid, octadecanedioic acid, eicosanedioic acid and triacontanedioic acid, and esterification products between said dicarboxylic acids or anhydrides thereof and diethylene glycol, thiodiethylene glycol or a

monoalkylene glycol.

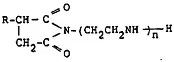
19. A composition as claimed in any one of the preceding claims, wherein the amount of the components (i), (ii) and (iii) is 0.01 to 2.0% by weight.

20. A composition as claimed in any one of the preceding claims, wherein the mixing weight ratio of the components (i) and (ii) to the component (iii) is from 10/90 to 90/10.

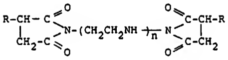
21. A composition as claimed in any one of the preceding claims, wherein the mixing weight ratio of the component (i) to the component (ii) is from 10/90 to 90/10.

22. A composition as claimed in any one of the preceding claims, wherein the mixing weight ratio of the component (i) to the component (iii) is from 20/80 to 80/20.

23. A composition as claimed in any one of the preceding claims, wherein the succinimide as the component (iv) is selected from the group consisting of mono- and bis- alkylsuccinimides represented by the following formulae:



and



wherein R represents an oligomer residue having a molecular weight of about 1000 and n is an integer of from 4 to 6,
and B-blocked succinimide.

24. A composition as claimed in any one of the preceding claims, wherein the amount of the component (iv) is 1.00 to 10.00% by weight based on the lubricating oil composition.

25. A composition as claimed in any one of the preceding claims, wherein the amount of the component (v) is 0.05 to 1.00% by weight based on the lubricating oil composition.

26. Use of a lubricating composition as claimed in any one of the preceding claims in an automatic transmission or a wet brake.

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EUROPEAN SEARCH REPORT

Application Number

EP 90 30 7209

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X Y A	DE-A-2 044 257 (SHELL) * Whole document *	1,6,10,18-22 14-17 2	C 10 M 141/10 C 10 M 163/00 C 10 M 169/04 // (C 10 M 141/10 C 10 M 129:42 C 10 M 129:76 C 10 M 133:04 C 10 M 133:56 C 10 M 135:24 C 10 M 137:02 C 10 M 137:04 C 10 M 137:08) (C 10 M 163/00 C 10 M 129:42 C 10 M 129:76 C 10 M 133:04 C 10 M 133:56 -/-
X Y	GB-A-1 180 389 (BRITISH PETROLEUM) * Whole document *	1,6,10,14,18-22 3,4-9,24,26	
X	GB-A-1 180 388 (BRITISH PETROLEUM) * Whole document *	1,6,10,11,14,18-22	
X Y	FR-A-2 547 311 (KAO et al.) * Whole document *	2 12,13	
Y	US-A-2 285 853 (DOWNING et al.) * Page 3, column 2, lines 1-4 *	12	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
Y	GB-A-1 302 894 (CASTROL LTD) * Page 8, line 10 *	13	C 10 M
Y	GB-A-1 009 197 (LUBRIZOL) * Page 9, line 43 - page 10, line 2 *	14-17	
D,Y	GB-A-2 182 948 (NIPPON OIL) * Whole document *	3-9,24,26	
D,Y	EP-A-0 286 996 (IDEMITSU KOSAN CO.) * Whole document * -/-	3-9,24,26	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15-10-1990	DE LA MORINERIE B.M.S.B.

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	FR-A-1 336 422 (SHELL) * Whole document * ---	23	C 10 M 135:24 C 10 M 137:02 C 10 M 137:04 C 10 M 137:08 C 10 M 159:24) (C 10 M 169/04 C 10 M 101:02) C 10 N 40:04
A	GB-A-1 236 740 (GEIGY) * Cl.; pages 3-5 * -----	1-26	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)

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THE HAGUE	15-10-1990	DE LA MORINERIE B.M.S.B.

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